AD NUMBER
ADA800054
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AUTHORITY
NSWC notice dtd 9 Feb 1976; NSWC notice dtd 9 Feb 1976

REEL-C 7238

A.T.I 205992

CONFIDENTIAL

U. S NAVAL PROVING GROUND
DAHLGREN, VIRGINIA

REPORT NO 1073

BOMBS AND ASSOCIATED COMPONENTS

50th Partial Report

BALLISTIC TEST OF 1000# LOW DRAG, G P. BOMB TYPE EX 10 MOD 12

Task
Assignment NPG-Re3c-321-1-52

FINAL Report

Copy No. 29

Classification CONFIDENTIAL
SECURITY INFORMATION

Ballistic Tests of 1000# Low Drag, G. P. Bomb Type EX 10 Mod 12

PART A

SYNOPSIS

1. The tests reported herein were conducted to determine: (1) the maximum STS armor plate thickness which the 1000 lb. Low Drag G.P. Bomb Type EX 10 Mod 12 will penetrate at 1000 ft./sec. velocity and remain in effective bursting condition; (2) the maximum thickness of reinforced structural concrete the bomb will penetrate at 1000 ft./sec. velocity and remain in effective bursting condition; (3) in accordance with reference (c) to compare bombs finished by heat treating with those finished by normalizing; (4) any points of weakness or cause of failure in the design, and (5) chemical and metallurgical properties of the bomb body.

2. It is concluded that:

a. The maximum STS armor plate thickness which the normalized bomb will penetrate and remain in effective bursting condition, at a velocity of 1000 ft./sec. and 20° obliquity, is nominal 1"25 plate, as reported in NPG Confidential Report Number 748. Bomb body deformation is probably not severe enough to cause deflagration of an explosive filler.

b. Under the same conditions, the corresponding thickness for the quenched and drawn bomb is nominal 1"38 STS armor plate. The two rounds fired under the above conditions remained effective and intact. Body deformation was probably not severe enough to cause deflagration of an explosive filler. It appears that the heat treated bomb will penetrate a greater thickness of STS armor plate than will the bomb finished by normalizing.

c. The maximum thickness of reinforced concrete which the heat treated bomb will penetrate and remain in effective bursting condition, at 1000 ft./sec. striking velocity and 20° obliquity, is 24 inches. Two bombs were fired satisfactorily under these conditions. Two additional bombs fired at 30 and 36 inches of reinforced concrete were not effective, both bombs breaking into two pieces.

d. No bombs finished by normalizing were fired at reinforced concrete during this test. However, from the results of a previous test as reported in NPG Report Number 748, it is apparent that under the same conditions the maximum thickness of reinforced concrete for the normalized bomb is also 24 inches.

e. Bombs heat treated by quenching in oil from 1500°F and drawing at 1100°F followed by a water quench have better ballistic qualities than those produced by normalizing only.

f. Quenched and drawn bombs have lower temperatures of transition from ductile to brittle behavior and thus would be more effective at low temperatures than normalized bombs.

3. It is recommended that the design of the nose fuze hole be reviewed for the purpose of strengthening the structures at this point.

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PART B

INTRODUCTION

1. AUTHORITY:

These tests were authorized by reference (a) and conducted under Task Assignment NPG-Re3c-321-1-52.

2. REFERENCES:

a. BUORD Conf ltr Re3c-LME:edb NP9 Ser 25671 of 14 Sep 1951
b. Task Assignment NPG-Re3c-321-1-52
c. NPG Conf Report Number 646
d. NPG Conf Report Number 748
e. National Tube Co. Preliminary Sk. Number 142

3. BACKGROUND:

In the development of a family of low drag bombs for external suspension on high speed aircraft, the Naval Proving Ground has conducted plate penetration tests and metallurgical examination on the 1000 lb. Low Drag G.P. Bomb Type EX 10 and Type EX 10 Mod 3. Reference (c) is a report on the performance of 1000 lb. Low Drag G.P. Bomb Type EX 10 together with recommendations for heat treatment of this bomb case to improve its metallurgical properties. Reference (d) is a report on the performance of 1000 lb. Low Drag G.P. Bomb Type EX 10 Mod 3 together with recommendations for heat treatment to improve its metallurgical properties. The Type EX 10 Mod 3 bomb differed from the Type EX 10 bomb in that inserts for screw-in suspension lugs were provided in the bomb body, the nose section of the bomb body was heavier, and the thread diameter of the nose fuze hole was increased to three inches.

This report deals with the performance of 1000 lb. Low Drag G.P. Bombs Type EX 10 Mod 12 in the heat-treated and in the normalized condition.

4. OBJECT OF TEST:

These tests were conducted to determine:

a. The maximum armor plate or concrete thickness which each type of bomb will penetrate and remain in an effective bursting condition.

b. The degree of acceptable deformation of each type of bomb resulting from impact.

c. The condition under which each type of bomb will fail.

d. The chemical and metallurgical properties of the bombs.

5. PERIOD OF TEST:

a.	Date Project Letter	14 September 1951
b.	Date Commenced Test	5 October 1951
c.	Date Completed Test	5 November 1951

PART C

DETAILS OF TEST

6. DESCRIPTION OF ITEM UNDER TEST:

Twenty 1000 lb. Low Drag G.P. Bombs Type EX 10 Mod 12 described by reference (e), which is included as Figure 10 in this report. The Type EX 10 Mod 12 bombs differ from Type EX 10 Mod 3 bombs in that the threads for the nose fuze hole have been increased to 3-1/2" diameter. In addition, ten of the EX 10 Mod 12 bombs were submitted for test with heat treatment as recommended by references (c) and (d); that is quenched in oil from 1500°F and drawn at 1100°F, followed by a water quench. The remaining ten bombs were submitted for test in the normalized condition to conform to the treatment given the Type EX 10 and Type EX 10 Mod 3 bombs in order that comparative tests might be conducted between normalized and heat treated bombs.

The twenty EX 10 Mod 12 bombs used in this test were inert loaded with a vermiculite-cement filler of 1.55 specific gravity.

7. DESCRIPTION OF TEST EQUIPMENT:

Gun:	14"/50 Mk 11 Mod 0, No. 119L-2
Charge:	Various weights of Sphero-Hexagonal Black Cannon Powder
Targets:	Nominal 1-1/4", 1-3/8" and 1-1/2" STS armor plate 24", 30" and 36" structural concrete reinforced 3 ways with 3/4" rod on 6" centers.

8. PROCEDURE:

The bombs were fired against STS armor plate targets of various thicknesses at velocities ranging from 838 ft./sec. to 922 ft./sec. The heat treated bombs were fired against the reinforced concrete targets at velocities ranging from 874 ft./sec. to 890 ft./sec. All tests were conducted with the target at 20° obliquity. The targets were secured in heavy butts and backed by a sand pile, which served as the recovery medium. Each type of bomb was recovered after firing and examined prior to firing the next test on this program. Velocities were measured in the standard manner, using solenoids and oscillographs. Samples were cut from each of the following listed bombs for metallurgical examination: NORM-2, NORM-9, Q & D-11, and Q & D-18.

9. RESULTS AND DISCUSSION:

a. Ballistic test conditions and results are given in detail in Tables III through XIV of Appendix (B) and Figures 1 through 9 of Appendix (C) and are summarized in Tables I and II of Appendix (A). Briefly, the results were as follows:

(1) Four of the normalized bombs were fired against STS armor. The first bomb was fired against 1"21 STS armor at 838 ft./sec. and was recovered in effective condition with moderate flattening on the body nose section. The next two bombs were fired against 1"38 STS at striking velocities of 922 ft./sec. and 865 ft./sec. Both bombs were recovered in ineffective condition, one being cracked from the nose to 26" back and the other having the nose section bent and broken open. The fourth round was fired against 1"21 STS at 899 ft./sec. and was recovered in an ineffective condition with the nose broken off. As a result of these tests, it was considered that the plate limit of the normalized 1000 lb. Low Drag G.P. Bomb Type EX 10 Mod 12 at these test conditions was less than nominal 1-1/4" STS armor plate.

(2) Four of the heat treated bombs were fired against STS armor plate. The first bomb was fired against 1"21 STS armor at 911 ft./sec. and was recovered in effective condition with moderate to severe flattening of the nose body section. The second bomb was fired against 1"38 STS armor at 855 ft./sec. and was recovered in effective condition with moderate flattening of the bomb body. The third round was fired against 1"50 STS armor at 872 ft./sec. and was recovered in ineffective condition being bent with the nose broken off. The fourth round was fired against

1"38 STS armor at 850 ft./sec. and was recovered in effective condition although severely worked on the nose section. As a result of these tests, it was considered that the plate limit of the heat treated 1000 lb. Low Drag G.P. Bomb Tvpe EX 10 Mod 12 at these test conditions was nominal 1-3/8" STS armor plate.

(3) Four of the heat treated bombs were fired against reinforced concrete targets. The first bomb was fired against 24" reinforced concrete at a striking velocity of 888 ft./sec. and was recovered in effective condition with very little body deformation. The second bomb was fired against 36" reinforced concrete at 890 ft./sec. and was rendered ineffective as the bomb broke into two pieces in the target. The third bomb was fired against 24" reinforced concrete at 874 ft./sec. and was recovered in effective condition with very little body deformation. The fourth round was fired against 30" reinforced concrete at 886 ft./sec. and was rendered ineffective as the bomb broke into two pieces in the target. As a result of these tests, it was considered that the heat treated 1000 lb. Low Drag G.P. Bomb Type EX 10 Mod 12 would penetrate in effective condition 24" reinforced concrete.

b. Metallurgical Examination

Metallurgical examination was made of normalized bombs #2 and #9 and quenched and drawn bombs #11 and #18 shown after firing in Figures 2, 5, 2 and 8 respectively. The examination consisted of chemical and spectrographic analysis, tensile, Charpy impact and Brinell hardness tests, hot acid etch and microscopic examination. The test samples were cut from the least damaged sections of the side walls of the bombs after firing.

The results of chemical and spectrographic analyses were as follows:

Bomb No.	C	Mn	P	S	Si	Mo	Cr	Ni
2 NORM	.42	1.75	.016	.021	.22	.32	.08	Trace
9 NORM	.34	1.37	.020	.021	.18	.31	.09	"
11 Q&D	.41	1.64	.016	.024	.18	.29	.09	"
18 Q&D	.37	1.64	.016	.021	.21	.32	.10	"

Ballistic Tests of 1000# Low Drag, G.P. Bomb Type EX 10 Mod 12

Longitudinal tensile test and average Brinell hardness results are shown below:

Bomb No.	Yld. Str. .2% p.s.i.	Ult. Str. p.s.i.	Elong. %1.4"	R.A. %	B.H.N. 3000 Kg.
#2 NORM	95500	123670	17.9	49.3	251
#9 NORM	65850	101670	23.1	53.2	202
#11 Q&D	90870	119670	20.2	61.9	249
#18 Q&D	107500	127000	17.5	58.1	270

The tensile test results are averages of three specimens from each bomb.

Longitudinal Charpy V-notch impact tests with the notch normal to the plate surface were made in duplicate at 100°C, +25°C (room temperature), 0°C, -40°C and -78°C excepting for bomb #2. On this bomb, the testing at -78°C was omitted and additional tests were made at +65°C and +45°C. The results of impact tests are shown in Table XV and Figures 11 and 12, Appendix (E).

Transverse sections etched for 20 minutes in 50% HCl-50% H_2O at 160°F are shown in Figure 13.

Typical microstructures at 250X and 1000X are shown in Figures 14 to 21, inclusive. Chemical analyses represent a non-standard manganese - molybdenum steel which is similar in composition to the analysis of previous bombs reported in references (c) and (d). The analysis of bomb #9 is somewhat lower in carbon and manganese contents which accounts for its softer physical properties. The tensile properties of the quenched and drawn bombs are not appreciably different from those of the normalized bombs previously examined, bomb #18 being only slightly harder. However, the beneficial effects of the quenched and drawn heat treatment manifests itself in the tempered-martensitic microstructure in Figures 18 to 21, inclusive, and in the combination of higher values of tensile, hardness and impact strengths exhibited by bombs #11 and #18. The deep acid etch tests as shown in Figure 13 indicate sound steel in all four bombs.

Considering the points on the Charpy impact curves in Figures 11 and 12, where the fractures become 50% granular and 50% fibrous as the transition points between toughness and brittleness, it will be noted that the normalized bombs #2 and #9 become brittle at temperatures of approximately plus 25°C and 0°C respectively, whereas the quenched and drawn bombs #11 and #18 become embrittled at approximately minus 50°C and below minus 78°C respectively. This indicates that the quenched and drawn bombs will be more effective at sub-zero temperatures than the normalized bombs.

PART D

CONCLUSIONS

10. It is concluded that:

a. The maximum STS armor plate thickness which the 1000 lb. Low Drag G.P. Bomb Type EX 10 Mod 12 in the normalized condition will penetrate and remain in effective bursting condition, at velocities ranging from 838 ft./sec. to 922 ft./sec. and 20° obliquity, is less than nominal 1-1/4" plate. This is to be compared with the 1000 lb. Low Drag G.P. Bomb Type EX 10 Mod 3 which effectively penetrated nominal 1-1/4" STS armor plate at the same test conditions. Both Mods of these Type EX 10 bombs are in the same heat treated condition, the only design difference being in the thread diameter of the nose fuze hole. Since the failures of the Type EX 10 Mod 12 bomb originated from or around the nose fuze hole, it is concluded that increasing the diameter of the nose fuze hole from 3" in the Type EX 10 Mod 3 bomb to 3-1/2" in the Type EX 10 Mod 12 bomb has resulted in decreasing the thickness of STS armor plate the bomb will penetrate in an effective condition.

b. The maximum STS armor plate thickness which the 1000 lb. Low Drag G.P. Bomb Type EX 10 Mod 12 in the heat treated condition will penetrate and remain in effective bursting condition, at velocities ranging from 850 ft./sec. to 911 ft./sec. and 20° obliquity, is nominal 1-3/8" plate.

c. The maximum thickness of reinforced concrete the 1000 lb. Low Drag G.P. Bomb Type EX 10 Mod 12 in the heat treated condition will penetrate and remain in effective bursting condition, at velocities of 874 ft./sec. and 888 ft./sec. and 20° obliquity, is 24".

d. Bombs heat treated by quenching in oil from 1500°F and drawing at 1100°F followed by a water quench have better ballistic qualities than those produced by normalizing only.

e. Quenched and drawn bombs have lower temperatures of transition from ductile to brittle behavior and thus would be more effective at low temperatures than normalized bombs.

PART E

RECOMMENDATIONS

11. It is recommended that the design of the nose fuze hole be reviewed for the purpose of strengthening the structure at this point.

Ballistic Tests of 1000# Low Drag, G.P. Bomb Type EX 10 Mod 12

The tests upon which this report is based were conducted by:
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By direction

CONFIDENTIAL

NPG REPORT NO. 1073

U. S. NAVAL PROVING GROUND
DAHLGREN, VIRGINIA

Fiftieth Partial Report

on

Bombs and Associated Components

- -

Final Report

on

Ballistic Tests of 1000# Low Drag, G.P. Bomb

Type EX 10 Mod 12

JAN 22 1953

Project No.: NPG-Re3c-321-1-52
Copy No.: 29
No. of Pages: 11

Date:

CONFIDENTIAL
SECURITY INFORMATION

Ballistic Tests of 1000# Low Drag, G.P. Bomb Type EX 10 Mod 12

TABLE I

Summary of Firing Conditions and Ballistic Test Results

Imp. No.	Bomb No.	Obl.	Thick-ness	Str. Vel. ft./sec.	Penet.	Thru Open	Condition
39328	NORM-1	20	1".21	838	C	14"X14"	Effective and intact. Moderate flattening.
39329	Q&D-12	20	1".21	911	C	14"X14"	Effective and intact. Moderate to severe flattening.
39334	NORM-2	20	1".38	922	C	14"X14"	Severely bent and drawn-sides flattened, cracked long from nose to 26" aft.
39335	Q&D-11	20	1".38	855	C	14"X14"	Effective and intact. Moderate flattening.
39351	NORM-4	20	1".38	865	C	14"X14"	Not effective- bent and broken open on nose section.
39352	Q&D-13	20	1".50	872	C	14"X14"	Not effective- bent and broken open on nose section.
39364	Q&D-14	20	1".38	850	C	14"X14"	Effective and intact. Severely worked on nose.
39365	NORM-9	20	1".21	899	C	14"X14"	Not effective- broken open on nose.
39376	Q&D-19	20	24"	888	C	18"X18"	Effective and intact. Very slightly bent and worked.

Ballistic Tests of 1000# Low Drag, G.P. Bomb Type EX 10 Mod 12

TABLE I (Continued)

Imp. No.	Bomb No.	Obl.	Thick-ness	Str. Vel. ft./sec.	Penet.	Thru Open	Condition
39387	Q&D-17	20	36"	890	35"	15"X20"	Bomb broke into 2 pieces. Nose through and off. Base stuck in block.
39416	Q&D-18	20	24"	874	C	19"X21"	Effective and intact. No. deformation.
39438	Q&D-20	20	30"	886	Inc.	8"X10"	Bomb broke into 2 pieces. Nose through and off. Base stuck in block.

TABLE II

Comparison of Heat Treated Bombs

Normalized			Quenched and Drawn		
1½21	838	OK	1½21	911	OK
1½38	922	NG	1½38	855	OK
1½38	865	NG	1½50	872	NG
1½21	899	NG	1½38	850	OK
			24"	888	OK
			36"	890	NG
			24"	874	OK
			30"	886	NG

File No.

Butt Firing

U. S. Naval Proving Ground

Dahlgren, Va. 10-5-51 194

IMPACT NO. 39329

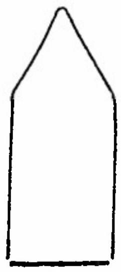
IMPACT DATE 10-5-51

BUTT NO. K

OBJECT BALLISTIC TEST OF [illegible] LB. LOW DRAG BOMB - TYPE EX-10

REFERENCE N.P.G. ~~LETTER~~ [illegible] 1623 DATED

PLATE		BOMB ~~PROJECTILE~~	
Gauge	1.250	Caliber	13.97
Class	STS	Maker	N.T. Co.
Maker	U.S. STEEL	Type	G.P. LOW DRAG
No.	145696	Lot No.	—
Group	U-536-778	Year of Specification	—
Contract	N60c-155-9778	Mark	EX-10
		Mod.	12
		No.	0+Q-12
Date received	4-25-51	Date received	
Dimensions	250" X 82 1/2"	~~Capped or~~ uncapped	
No. of impact on plate	4	~~Weight (capped)~~	
Thickness at impact	1.21	Weight (uncapped)	934#
OBLIQUITY	20°	Length (uncapped)	78.80
Impact dimensions	14" X 15"	Fuze	NONE
PENETRATION	COMPLETE	Filler	VERMICULITE
Flaking front	C	Flight by screen	
Flaking back	C	Condition after firing:-	
Dist. from top, ~~bottom~~	55"	EFFECTIVE or ~~INEFFECTIVE~~	
Dist. from right, ~~left~~	85"		
Dist. from nearest impact	27"	moderate to severe	
Dish	4"	flattening.	
Spur	6"		
Cracks - Bulge	C		
Button (Thrown) ~~(Started)~~			
Through Opening	14" X 14"		



BALLISTIC DATA

NOTE: All limits are for this plate and this obliquity only.	-1- Desired	-2- Oscillograph	-3- Chronograph	-4- Limit, estimated for this thickness of impact.	-5- Actual adjusted to nominal gauge	-6- Limit, for nominal gauge, based on this impact only. (Adjusted from column 4)	-7- Limit, for nominal gauge, established from column 6 and previous impacts.
		11:LRM					
Striking velocity (f.s.)		811					

REMARKS

Limit shots only

e/d

F(e/d, θ)

N.P.G. Photo. No. [illegible]

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SECURITY INFORMATION

~~Acceptance or Rejection recommended~~

[illegible signature]

~~U. S.~~ Navy

TABLE IV

GUN: 14"/50 [illegible] MOD 0 #11912

File No.

Butt Firing

U. S. Naval Proving Ground

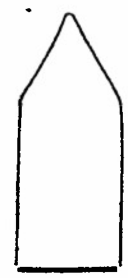
Dahlgren, Va. 10-9-51 194

IMPACT No. 39334
IMPACT DATE 10-9-51
BUTT No. B

OBJECT BALLISTIC TEST OF 1000 LB. LOW DRAG G.P. BOMB TYPE EX 10

REFERENCE N.P.G. ~~LETTER~~ Report No. 1023 DATED

PLATE		Bomb ~~PROJECTILE~~	
Gauge	1.38	Caliber	13.976
Class	STS	Maker	N.T. Co.
Maker	CARNEGIE	Type	LOW DRAG G.P.
No. 045701	Group C-526-392	Lot No. —	Year of Specification —
Contract	ORDER-437-5-5000-C	Mark EX 10	Mod. 12 No. NORM. 2
Date received	SEPT. 11, 1944	Date received	—
Dimensions	95 1/16" X 249 1/2"	~~Capped or~~ uncapped	
No. of impact on plate	4	~~Weight (capped)~~	
Thickness at impact	1.38"	Weight (uncapped)	931.50#
OBLIQUITY	20°	Length (uncapped)	928.00#
Impact dimensions	14" X 15"	Fuze	NONE
PENETRATION	COMPLETE	Filler	VERMICULITE
Flaking front	0	Flight by screen	
Flaking back	0	Condition after firing:-	
Dist. from top, ~~bottom~~	29"	~~EFFECTIVE or~~ INEFFECTIVE	
Dist. from right, ~~left~~	88"		
Dist. from nearest impact	72"	Severely bent and diameter	
Dish	3"	sides flattened cracked	
Spur	4"	long from nose to	
Cracks - Bulge	0	26" aft.	
Button (Thrown)~~(Started)~~			
Through Opening	14" X 14"		



BALLISTIC DATA

NOTE: All limits are for this plate and this obliquity only.	-1- Desired	-2- Oscillograph	-3- Chronograph	-4- Limit, estimated for this thickness of impact.	-5- Actual, adjusted to nominal gauge.	-6- Limit, for nominal gauge, based on this impact only. (Adjusted from column 4)	-7- Limit, for nominal gauge, established from column 6 and previous impacts.
		MEAN					
Striking velocity (f.s.)		922					

REMARKS

Limit shots only

e/d

F(e/d, Θ)

N.P.G. Photo. No. NPG 51397

CONFIDENTIAL
SECURITY INFORMATION

~~Acceptance or Rejection recommended~~

W.W. [illegible]
Ord. Engr. ~~U. S. Navy~~

TABLE V

GUN: 14"/50 MK 11 MOD- #11942

File No.

Butt Firing

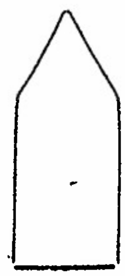
U. S. Naval Proving Ground
Dahlgren, Va. 10-9-51 194

IMPACT NO. 39335
IMPACT DATE 10-9-51
BUTT NO. B

OBJECT BALLISTIC TEST OF 1000 LOW DRAG G.P. BOMB TYPE EX 10

REFERENCE N.P.G. ~~LETTER~~ Report No. [illegible] DATED

PLATE		BOMB ~~PROJECTILE~~	
Gauge	1.38"	Caliber	13.977
Class	STS	Maker	N.T. Co.
Maker	CARNEGIE	Type	G.P. LOW DRAG
No.	045701 Group C-526-392	Lot No.	— Year of Specification —
Contract	ORDER-437-5-5000-C	Mark	EX 10 Mod. 12 No. D&G-11
Date received	SEPT. 11, 1944	Date received	—
Dimensions	95-1/16" X 249-1/2"	~~Capped or~~ uncapped	
No. of impact on plate	5	~~Weight (capped)~~	
Thickness at impact	1.38"	Weight (uncapped)	928.0#
OBLIQUITY	30°	Length (uncapped)	78.90#
Impact dimensions	14"X15"	Fuze	NONE
PENETRATION	COMPLETE	Filler	VERMICULITE
Flaking front	0	Flight by screen	
Flaking back	0	Condition after firing:-	
Dist. from top, ~~bottom~~	67"	EFFECTIVE or ~~INEFFECTIVE~~	
Dist. from right, ~~left~~	89"		
Dist. from nearest impact	33"	Moderate flattening.	
Dish	3"		
Spur	6"		
Cracks - Bulge	0		
Button (Thrown)(~~Started~~)			
Through Opening	14"X14"		



BALLISTIC DATA

NOTE: All limits are for this plate and this obliquity only.	-1- Desired	-2- Oscillograph	-3- Chronograph	-4- Limit, estimated for this thickness of impact.	-5- Actual adjusted to nominal gauge.	-6- Limit, for nominal gauge, based on this impact only. (Adjusted from column 4)	-7- Limit, for nominal gauge, established from column 6 and previous impacts.
		MEAN					
Striking velocity (f.s.)		855					

REMARKS

Limit shots only

e/d

F(e/d, θ)

N.P.G. Photo. No. NPG 51397

GUN: 14"/50 MK 11 Mod — #11962

CONFIDENTIAL
SECURITY INFORMATION

~~Acceptance or Rejection recommended.~~

W.W. Myers
Ord. Eng.
~~U. S. Navy~~

TABLE VI

File No.

Butt Firing

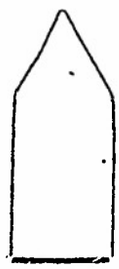
U. S. Naval Proving Ground
Dahlgren, Va. 10-11-51 194

IMPACT NO. 39351
IMPACT DATE 10-11-51
BUTT NO. E

OBJECT BALLISTIC TEST OF 1000 LB. G.P. LOW DRAG BOMB TYPE EX 10

REFERENCE N.P.G. ~~LETTER~~ [illegible] DATED

PLATE		Bomb	~~PROJECTILE~~
Gauge	1.38	Caliber	13.972.
Class	STS	Maker	N.T.Co.
Maker	CARNEGIE	Type	G.P. LOW DRAG
No.	045201 Group C-526-392	Lot No.	— Year of Specification —
Contract	ORDER-437-S.5000-C.	Mark	EX10 Mod. 12 No. NORD-4
Date received	SEPT. 11, 1944	Date received	—
Dimensions	95/16" X 249/32"	~~Capped~~ or uncapped	
No. of impact on plate	6	~~Weight (capped)~~	
Thickness at impact	1.38	Weight (uncapped)	938.0#
OBLIQUITY	20°	Length (uncapped)	78.70"
Impact dimensions	14" X 15"	Fuze	NONE
PENETRATION	COMPLETE	Filler	VERMICULITE
Flaking front	0	Flight by screen	
Flaking back	0	Condition after firing:-	
Dist. from top, ~~bottom~~	31".	~~EFFECTIVE or~~ INEFFECTIVE	
Dist. from ~~right,~~ left	128"	Bent and broken open on nose section	
Dist. from nearest impact	33"		
Dish	3"		
Spur	7"		
Cracks - Bulge	0		
Button (Thrown) ~~(Started)~~			
Through Opening	14" X 14"		



BALLISTIC DATA

NOTE: All limits are for this plate and this obliquity only.	-1- Desired	-2- Oscillograph MEAN	-3- Chronograph	-4- Limit, estimated for this thickness of impact.	-5- Actual, adjusted to nominal gauge.	-6- Limit, for nominal gauge, based on this impact only. (Adjusted from column 4)	-7- Limit, for nominal gauge, established from column 6 and previous impacts.
Striking velocity (f.s.)		865					

REMARKS

CONFIDENTIAL
SECURITY INFORMATION

Limit shots only ~~Acceptance or Rejection recommended~~

e/d

F(e/d, Θ)

N.P.G. Photo. No. NP 51398

Ord Engr ~~U.S. Navy~~

GUN: 14"/50 MK II MOD - #11912

TABLE VII

File No.

Butt Firing

U. S. Naval Proving Ground
Dahlgren, Va. 10-11-51 ~~194-~~

IMPACT NO. 39352.
IMPACT DATE 10-11-51
BUTT NO. B

OBJECT BALLISTIC TEST OF 1000 LB. G.P. LOW DRAG BOMB TYPE EX 10

REFERENCE N.P.G. ~~LETTER~~ [illegible] DATED

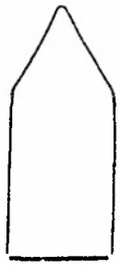
PLATE

Gauge 1"50
Class STS
Maker UNITED STEEL
No. C22615 Group U-526-773
Contract N-600-155s-7931
Date received 4-11-51
Dimensions 95" X 250"
No. of impact on plate
Thickness at impact 1."50
OBLIQUITY 20°
Impact dimensions 15" X 16"
PENETRATION CONE-EYE
Flaking front 0
Flaking back 0
Dist. from top, ~~bottom~~ 58"
Dist. from ~~right~~, left 144'
Dist. from nearest impact 39"
Dish 3"
Spur 5"
Cracks - Bulge 0
Button (Thrown) ~~(Started)~~
Through Opening 14" X 14"

~~PROJECTILE~~ BOMB

Caliber 13,973
Maker N.T. Co.
Type G.P. LOW DRAG
Lot No. — Year of Specification —
Mark EX.10 Mod. 12 No. DTG-13
Date received —
~~Capped or~~ uncapped
~~Weight (capped)~~
Weight (uncapped) 917.0 #
Length (uncapped) 78.20"
Fuze NONE
Filler PERMONITE
Flight by screen
Condition after firing:-
~~EFFECTIVE or~~ INEFFECTIVE

Bent and broken open on nose section.



BALLISTIC DATA

NOTE: All limits are for this plate and this obliquity only.	-1- Desired	-2- Oscillograph MEAN	-3- Chronograph	-4- Limit, estimated for this thickness of impact	5 Actual adjusted to nominal gauge	-6- Limit, for nominal gauge, based on this impact only (Adjusted from column 4)	-7- Limit, for nominal gauge, established from column 6 and previous impacts
Striking velocity (f.s.)		872.					

REMARKS

CONFIDENTIAL
SECURITY INFORMATION

Limit shots only
~~Acceptance or Rejection recommended~~
e/d
F(e/d, 6)

W. W. Mengel
Capt. USN

N.P.G. Photo. No. NPG-51399

~~U.S. Navy~~
TABLE VIII

GUN: 14"/50 MK 11 MOD - # 11912

File No.

Butt Firing

U. S. Naval Proving Ground

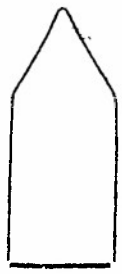
Dahlgren, Va. 10-15-51 ~~194~~

IMPACT No. 393 (?)
IMPACT DATE 10-15-51
BUTT No. E

OBJECT Ballistic Test of 1000 LB. G.P. Low Drag Bomb Type EX10

REFERENCE N.P.G. ~~LETTER~~ Report No 1073 DATED

PLATE		Bomb ~~PROJECTILE~~	
Gauge	1.38	Caliber	14"
Class	STS	Maker	N.T. Co.
Maker	CARNEGIE	Type	G.P. Low Drag
No. 045701	Group C-526-392	Lot No.	Year of Specification
Contract	ORDEF-437-5-5000-C	Mark EX10	Mod. 12 No. DY914
Date received	SEPT. 11, 1944	Date received	
Dimensions	95 1/16" x 249 1/2"	~~Capped or~~ uncapped	
No. of impact on plate	7	~~Weight (capped)~~	
Thickness at impact	1.38	Weight (uncapped)	938.0#
OBLIQUITY	20°	Length (uncapped)	72.40"
Impact dimensions	14" x 16"	Fuze	NONE
PENETRATION	Complete	Filler	[illegible]
Flaking front	0	Flight by screen	
Flaking back	0	Condition after firing:-	
Dist. from top, ~~bottom~~	60"	EFFECTIVE or ~~INEFFECTIVE~~	
Dist. from ~~right~~, left	123"		
Dist. from nearest impact	36"	Severely warped [illegible]	
Dish	2"		
Spur	8"		
Cracks - Bulge	0		
Button (Thrown)(~~Started~~)			
Through Opening	19" x 16"		



BALLISTIC DATA.

NOTE: All limits are for this plate and this obliquity only.	-1- Desired	-2- Oscillograph	-3- Chronograph	-4- Limit, estimated for this thickness of impact	-5- Actual adjusted to nominal gauge.	-6- Limit, for nominal gauge, based on the impact only. (Adjusted from column 4)	-7- Limit, for nominal gauge, established from column 6 and previous impacts
		MEAN					
Striking velocity (f.s.)		850					

REMARKS.

CONFIDENTIAL

SECURITY INFORMATION

Limit shots only

e/d

F(e/d, θ)

~~Acceptance or Rejection recommended~~

W.T. Magir (?)
Ord. Eng. ~~U. S. Navy~~

N.P.G. Photo. No. NPG 51398

GUN: 14"/50 MK 11 #11912

TABLE IX

File No.............

Butt Firing

U. S. Naval Proving Ground

Dahlgren, Va. 10-16-51 194...

IMPACT NO. 39265

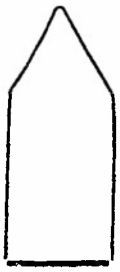
IMPACT DATE 10-16-51

BUTT NO. 2

OBJECT BALLISTIC TEST OF 16" AP. G.P. LOW DRAG BOMB

REFERENCE N.P.G. LETTER Project No. 1033 Bomb DATED

PLATE		PROJECTILE	
Gauge	1.25"	Caliber	14"
Class	STS	Maker	N. T. Co.
Maker	U. S. STEEL	Type	G. P. LOW DRAG
No. C45690	Group 35-36-998	Lot No.	Year of Specification
Contract	N60-1553-9928	Mark EX 10 Mod. 0	No. NUL-9
Date received	4-25-51	Date received	–
Dimensions	88" X 250"	~~Capped~~ or uncapped	
No. of impact on plate	5	~~Weight (capped)~~	
Thickness at impact	1.210	Weight (uncapped)	931.0#
OBLIQUITY	20°	Length (uncapped)	79.00
Impact dimensions	14" X 16"	Fuze	NONE
PENETRATION	COMPLETE	Filler	[illegible]
Flaking front	0	Flight by screen	
Flaking back	0	Condition after firing:-	
Dist. from top, ~~bottom~~	55"	~~EFFECTIVE or~~ INEFFECTIVE	
Dist. from ~~right,~~ left	118"		
Dist. from nearest impact	40"	Broken open on nose.	
Dish	8"		
Spur	2"		
Cracks - Bulge	0		
Button (Thrown) ~~(Started)~~			
Through Opening	14" X 15"		



BALLISTIC DATA

NOTE: All limits are for this plate and this obliquity only.	-1- Desired	-2- Oscillograph	-3- Chronograph	-4- Limit, estimated for this thickness of impact.	-5- Actual, adjusted to nominal gauge.	-6- Limit, for nominal gauge, based on this impact only. (Adjusted from column 4)	-7- Limit, for nominal gauge, established from column 6 and previous impacts.
		MEAN					
Striking velocity (f.s.)		899					

REMARKS

CONFIDENTIAL
SECURITY INFORMATION

Limit shots only

e/d

F(e/d, θ)

N.P.G. Photo. No. NPG-51400

GUN: 14"/50 MK. 11 #119L2

~~Acceptance or Rejection recommended~~

W.W. Meyer
Ord Eng
~~U. S. Navy~~

TABLE X

File No..........

Butt Firing

U. S. Naval Proving Ground

Dahlgren, Va. 10-18-51 194

IMPACT NO. 39376

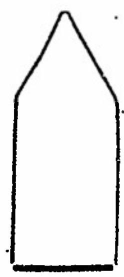
IMPACT DATE 10-18-51

BUTT NO. B

OBJECT Ballistic Test of 1000 LB. G.P. Bomb Type EX 10 Mod. 12

REFERENCE N.P.G. ~~LETTER~~ Report No. 1023 DATED

~~PLATE~~		Bomb ~~PROJECTILE~~	
Gauge	34" Concrete Block	Caliber	13.974"
Class		Maker	N. T. Co.
Maker		Type	G.P. Low Drag
No.	No Number. Group	Lot No.	— Year of Specification —
Contract		Mark	EX 10 Mod. 12 No. DTG-19
Date received		Date received	—
Dimensions	10' X 10'	~~Capped or~~ uncapped	
No. of impact on plate		~~Weight (capped)~~	
Thickness at impact	34"	Weight (uncapped)	933.6#
OBLIQUITY	90°	Length (uncapped)	78.56
Impact dimensions	16" X 27"	Fuze	None
PENETRATION	Complete	Filler	Vermiculite
Flaking front	50" X 59"	Flight by screen	
Flaking back	52" X 66"	Condition after firing:-	
Dist. from top, ~~bottom~~	72"	EFFECTIVE ~~or INEFFECTIVE~~	
Dist. from ~~right,~~ left	68"	Intact —	
Dist. from nearest impact	0		
Dish	0	Very slightly bent	
Spur	0		
Cracks - Bulge	0		
Button (Thrown)(Started)	—		
Through Opening	15" X 24"		



BALLISTIC DATA

NOTE: All limits are for this plate and this obliquity only.	-1- Desired	-2- Oscillograph	-3- Chronograph	-4- Limit, estimated for this thickness of impact.	-5- Actual, adjusted to nominal gauge.	-6- Limit, for nominal gauge, based on this impact only. (Adjusted from column 4)	-7- Limit, for nominal gauge, established from column 6 and previous impacts.
		MEAN					
Striking velocity (f.s.)		888					

REMARKS Bomb modified for firing. The concrete Block has 3/4" [illegible] marks at 2" centers. Bomb [illegible] found intact very slightly bent and cracked.

Limit shots only

e/d

F(e/d, Θ)

N.P.G. Photo. No. NPG-51401

CONFIDENTIAL

SECURITY INFORMATION

~~Acceptance or Rejection recommended~~

[signature]

CDR U. S. Navy

GUN: 14"/50 MK 11 MOD 0 # 11962

TABLE XI

File No. ....

Butt Firing

U. S. Naval Proving Ground

Dahlgren, Va. 10/25/1951 ~~194~~

IMPACT No. 39387

IMPACT DATE 10-25-51

BUTT No. B

OBJECT BALLISTIC TEST OF 1000 Lb G.P. LOW DRAG Bomb MK Ex10-12

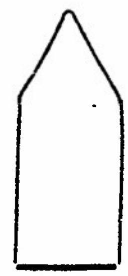
REFERENCE N.P.G. ~~LETTER~~ Project No. 1073 DATED

~~PLATE~~		PR~~OJECTI~~LE BOMB	
Gauge	36" CONCRETE BLOCK	Caliber	14"
Class		Maker	N.T. Co
Maker		Type	G.P. LOW DRAG
No.	11	Group	
		Lot No.	
		Year of Specification	
Contract		Mark	Ex 10
		Mod.	12
		No.	D+Q-17
Date received		Date received	
Dimensions		Capped or uncapped	
No. of impact on plate	1	Weight (capped)	
Thickness at impact	36"	Weight (~~uncapped~~)	943.0#
OBLIQUITY	20°	Length (~~uncapped~~)	78".65
Impact dimensions	36"X37"	Fuze	NONE
PENETRATION	PARTIAL	Filler	VERMICULITE
Flaking front	70"X80"	Flight by screen	
Flaking back	NONE		
Dist. from top, ~~bottom~~	82"		
Dist. from ~~right~~, left	41"		
Dist. from nearest impact	0		
Dish	NONE		
Spur	NONE		
Cracks - Bulge	NONE		
Button (Thrown)(Started)	NONE		
Through Opening	15"X20"		

Condition after firing:-

~~EFFECTIVE or~~ INEFFECTIVE

Broke into two pieces - Nose through and the Base stuck in block



BALLISTIC DATA

NOTE: All limits are for this plate and this obliquity only.	-1- Desired	-2- Oscillograph	-3- Chronograph	-4- Limit, estimated for this thickness of impact.	-5- Actual, adjusted to nominal gauge.	-6- Limit, for nominal gauge, based on this impact only. (Adjusted from column 4)	-7- Limit, for nominal gauge, established from column 6 and previous impacts.
		MEAN					
Striking velocity (f.s.)		890					

REMARKS Block has 3/4" REINFORCING RODS SPACED AT 6" CENTERLINES. The bomb broke in two. The nose went through the concrete block and the [illegible] of bomb stuck in the [illegible]

Limit ~~shots~~ only

e/d

F(e/d, Θ)

CONFIDENTIAL

SECURITY INFORMATION

Acceptance or Rejection recommended

E. [signature]

LCDR U.S. Navy

TABLE XII

N.P.G. Photo. No. NPG-51402

Gun 14/50 Mk 11-0 No 119-L-2

File No. 1

Butt Firing

U. S. Naval Proving Ground

Dahlgren, Va. 194

IMPACT NO. 39416

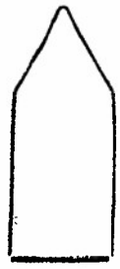
IMPACT DATE 10/30/51

BUTT NO. Butt "B"

OBJECT Ballistic Test of 1000 lb. G.P. Low Drag Bomb Mk Ex10-12 (DAN&G-18)

REFERENCE N.P.G. ~~LETTER~~ Report No. 1128 DATED

PLATE		PROJECTILE	
Gauge	24"	Caliber	14"
Class	Concrete Block	Maker	N.T.Co.
Maker	N.P.G.	Type	G.P. Low Drag
No.	Group	Lot No.	Year of Specification
Contract		Mark Ex10 Mod. 12	No. DAG-18
Date received		Date received	
Dimensions	144"x144"x24"	Capped or uncapped	
No. of impact on plate	1	Weight (capped)	
Thickness at impact	24"	Weight (~~uncapped~~)	947 lb
OBLIQUITY	20°	Length (~~uncapped~~)	78".20
Impact dimensions	35"x39"	Fuze	
PENETRATION	Complete	Filler	Vermiculite
Flaking front	56"x60"	Flight by screen	
Flaking back	51"x59"	Condition after firing:-	
Dist. from top, ~~bottom~~	74"	EFFECTIVE ~~or INEFFECTIVE~~	
Dist. from ~~right~~, left	72"	Intact	
Dist. from nearest impact	0		
Dish	None	No Deformation	
Spur	None		
Cracks - Bulge	None		
Button (Thrown)(~~Started~~)			
Through Opening	19"x21"		



BALLISTIC DATA

NOTE: All limits are for this plate and this obliquity only.	-1- Desired	-2- Oscillograph	-3- Chronograph	-4- Limit, estimated for this thickness of impact	-5- Actual, adjusted to nominal gauge.	-6- Limit, for nominal gauge, based on this impact only. (Adjusted from column 4)	-7- Limit, for nominal gauge, established from column 6 and previous impacts.
Striking velocity (f.s.)	1000	874					

REMARKS Bomb Modified For Firing Fr. Concrete Block Had 3/4" Reinforcing Rods At 6" Centers Bomb Effective And Intact No Deformation Of Bomb Due To Impact

Limit shots only

CONFIDENTIAL

SECURITY INFORMATION

Acceptance or Rejection recommended

e/d

F(e/d, Θ)

N.P.G. Photo. No. NP9-51403

E. Lenzik

E. LENZIK

LCDR. U. S. Navy

TABLE XIII

File No. ....

Butt Firing

U. S. Naval Proving Ground

Dahlgren, Va. 11-5-51 194

IMPACT NO. 39438

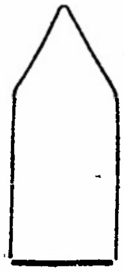
IMPACT DATE 11-5-51

BUTT NO. B

OBJECT Ballistic test of 1000 lb. G.P. Low Drag Bomb EX 10-12.

REFERENCE N.P.G. ~~LETTER~~ Report No. 1073 DATED

PLATE		PROJECTILE (Bomb G.P. Low Drag)	
Gauge	Concrete Target, 30"	Caliber	13.962
Class	Concrete	Maker	N.T.Co.
Maker	NPG	Type	G.P. Low Drag
No.	#12 Group	Lot No. / Year of Specification	
Contract		Mark	EX-10 Mod. 13 No. 04020
Date received		Date received	
Dimensions		~~Capped or~~ uncapped	
No. of impact on plate		~~Weight (capped)~~	
Thickness at impact	30".0	Weight (uncapped)	931.00#
OBLIQUITY	30°	Length (uncapped)	78.40
Impact dimensions	35" x 45"	Fuze	None
PENETRATION	Partial	Filler	Vermiculite
Flaking front	55" x 86"	Flight by screen	
Flaking back	28" x 36"	Condition after firing:-	
Dist. from top, ~~bottom~~	78"	~~EFFECTIVE or~~ INEFFECTIVE	
Dist. from ~~right~~, left	51"	Bomb broke into 2 pieces - nose through and aft - base stuck in block.	
Dist. from nearest impact	0		
Dish	0		
Spur	0		
Cracks - Bulge	0		
Button (Thrown)(Started)			
Through Opening	9" x 10"		



BALLISTIC DATA

NOTE: All limits are for this plate and this obliquity only.	-1- Desired	-2- Oscillograph	-3- Chronograph	-4- Limit, estimated for this thickness of impact.	-5- Actual, adjusted to nominal gauge.	-6- Limit, for nominal gauge, based on this impact only. (Adjusted from column 4)	-7- Limit, for nominal gauge, established from column 6 and previous impacts.
		Mean					
Striking velocity (f.s.)		886					

REMARKS

CONFIDENTIAL

SECURITY INFORMATION

Limit shots only

~~Acceptance or Rejection recommended~~

e/d

F(e/d, Θ)

W.W. Thompson
Ord. Eng. ~~U.S. Navy~~

N.P.G. Photo. No. NPG-51404

GUN: 14"/50 MK 11-0 # 119E3

TABLE XIV

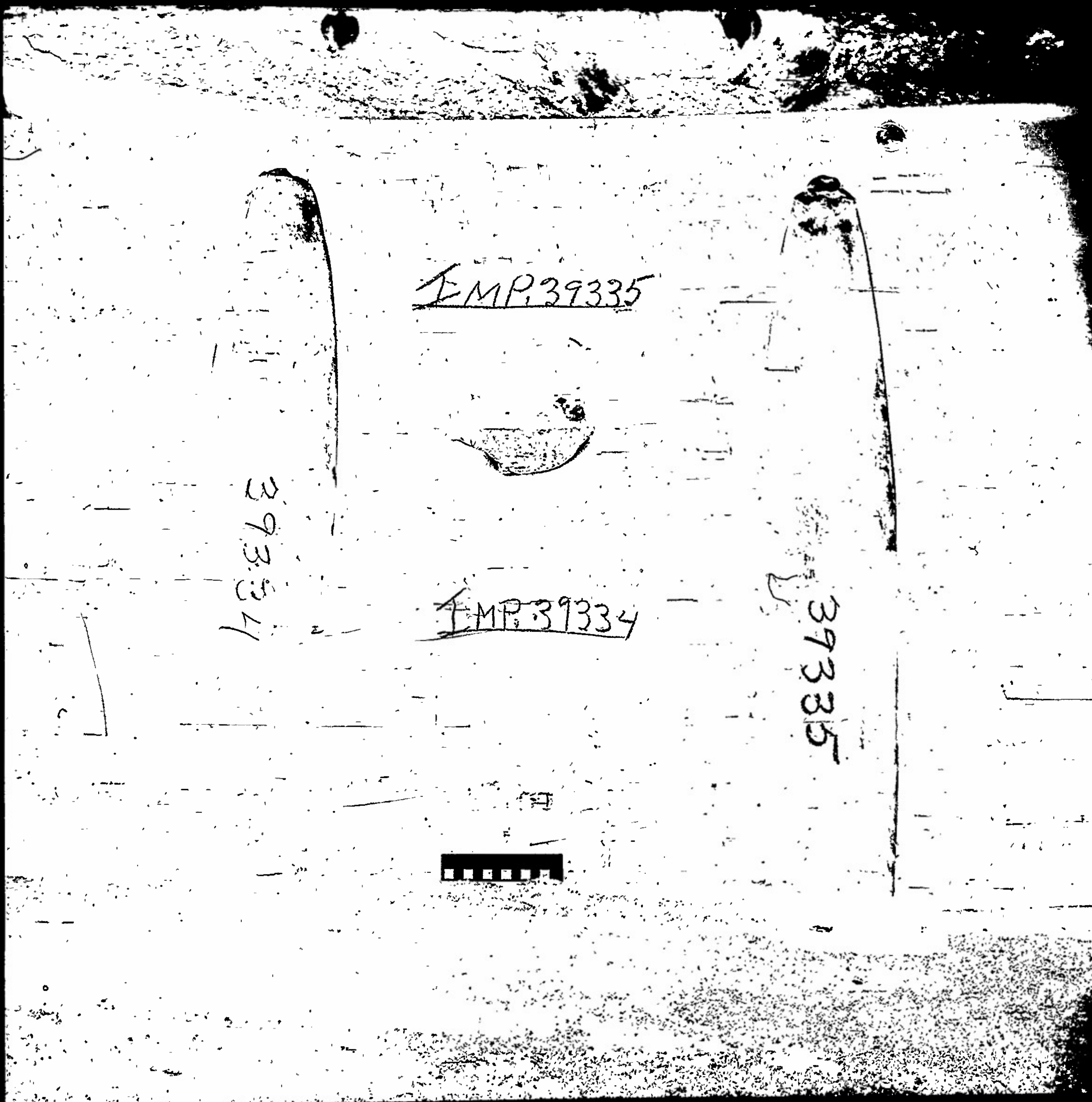
CONFIDENTIAL
SECURITY INFORMATION

NP9-51396 Figure 1 5 October 1951

Ballistic Test of 1000 lb. Low Drag, G.P. Bomb Type EX 10 Mod 12.

Imp. No.	Obl.	Thick.	S.V. f/s	Pene.	Remarks
39328	20°	1.21	838	C	Effective and intact-moderate flattening.
39329	20°	1.21	911	C	Effective and intact-moderate to severe flattening.

APPENDIX C



CONFIDENTIAL
SECURITY INFORMATION

NP9-51397 Figure 2 9 October 1951

Ballistic Test of 1000 lb. Low Drag, G.P. Bomb Type EX 10 Mod 12

Imp. No.	Obl.	Thick.	S.V. f/s	Pene.	Remarks
39334	20°	1"38	922	C	Not effective - severely bent and drawn. Sides flattened cracked long from nose to 26" aft.
39335	20°	1"38	855	C	Effective [illegible] intact- [illegible] flatten[illegible].

APPENDIX C

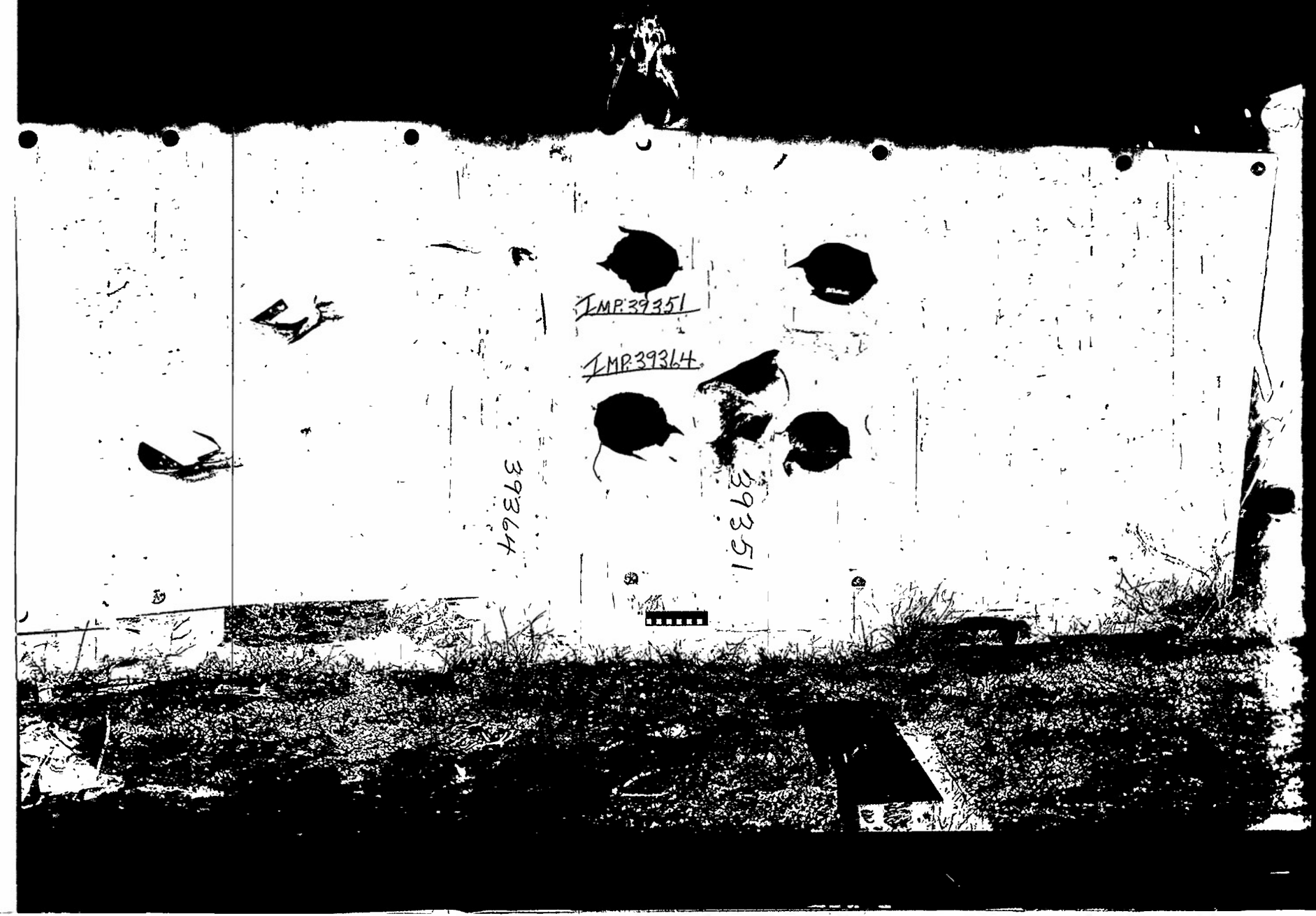
NP9-51398

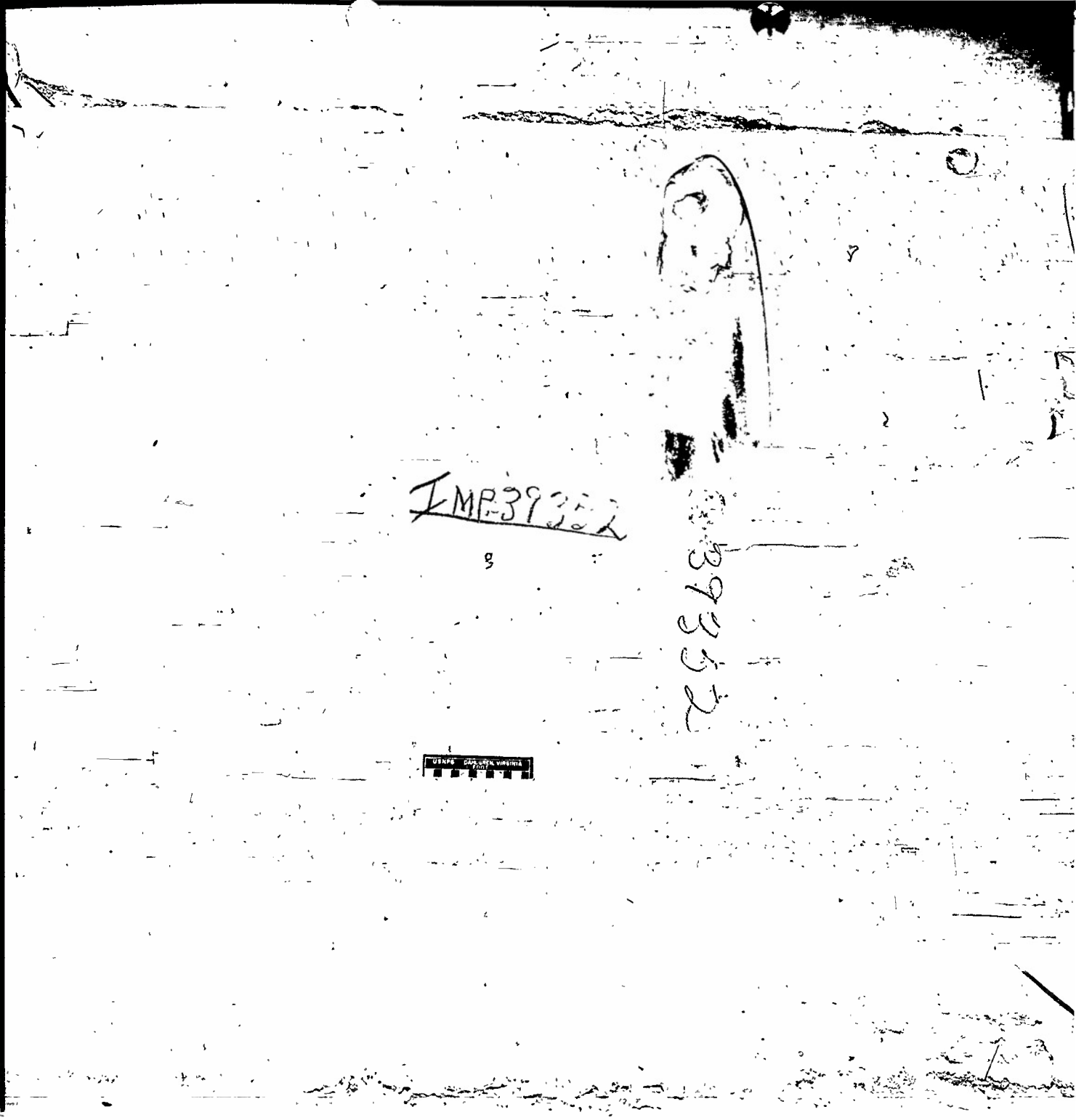
Figure 3 11 and 15 October 1951

Ballistic Test of 1000 lb. Low Drag, G.P. Bomb Type EX 10 Mod 12.

Imp. No.	Obl.	Thick.	S.V. f/s	Pene.	Remarks
39351	20°	1.38	865	C	Not effective - bent and broken open on nose section
39364	20°	1.38	850	C	Effective and intact - severely worked on nose.

APPENDIX C





IMP-39352

39352

NP9-51399 Figure 4 11 October 1951

CONFIDENTIAL
SECURITY INFORMATION

Ballistic Test of 1000 lb. Low Drag, G.P. Bomb Type EX 10 Mod 12.

Imp. No.	Obl.	Thick.	S.v. f/s	Pene.	
39352	20°	1.50	872	0	Not effective - bent and broken open on nose section.

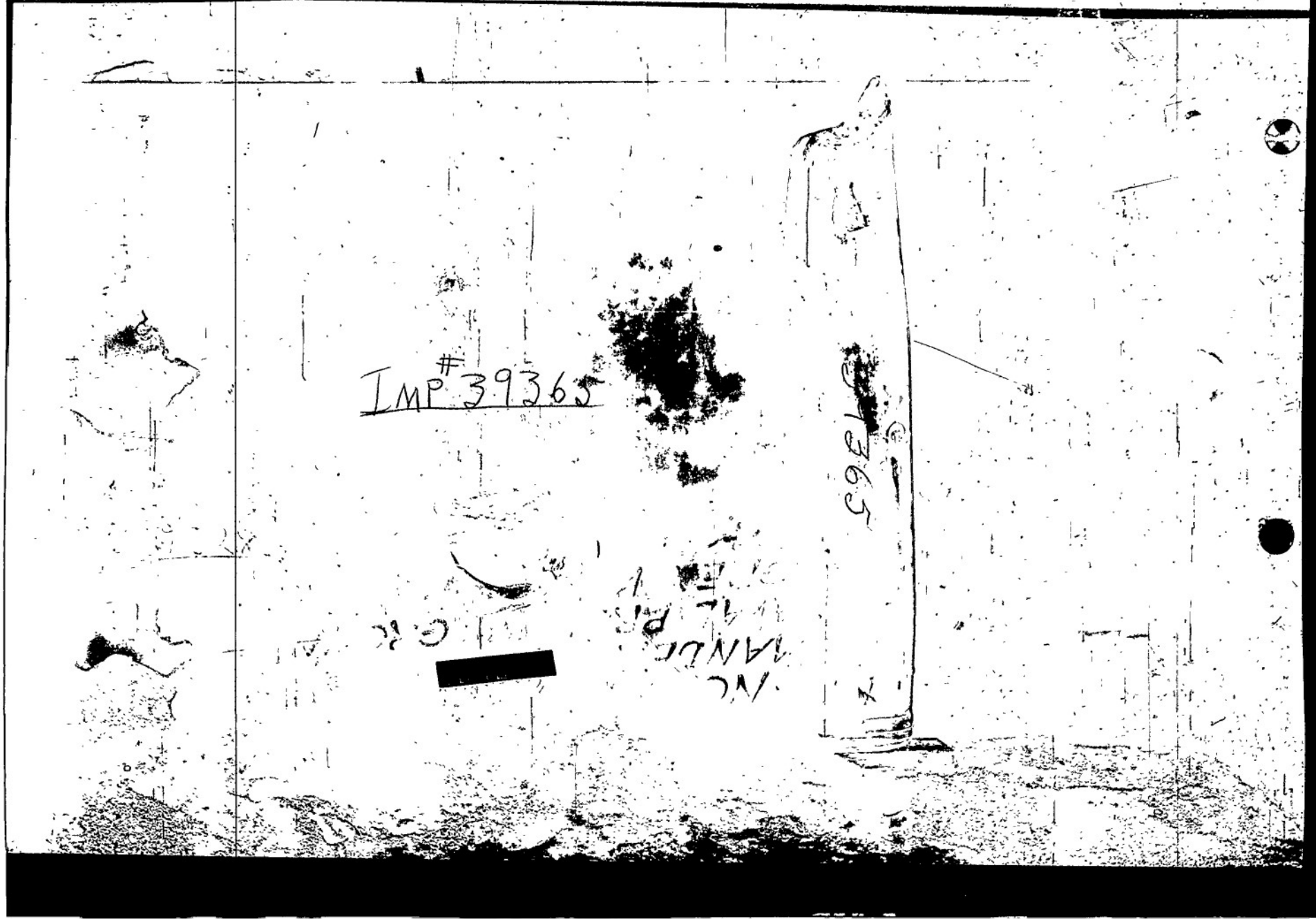
APPENDIX C

NP9-51400 Figure 5 16 October 1951

Ballistic Test of 1000 lb. Low Drag, G.P. Bomb Type MK 10 Mod 12.

Imp. No.	Obl.	Thick.	S.V. f/s	Pene.	Remarks
39365	20°	1.21	899	C	Not effective - broken open on nose.

APPENDIX C



NP9-51401 Figure 6 15 October 1951

Ballistic Test of 1000 lb. Low Drag, G.P. Bomb Type EX 10 Mod 12.

Imp. No.	Obl.	Thick.	S.V. f/s	Pene.	Remarks
39376	20°	24"	388	C	Effective and intact - very slightly bent and worked.

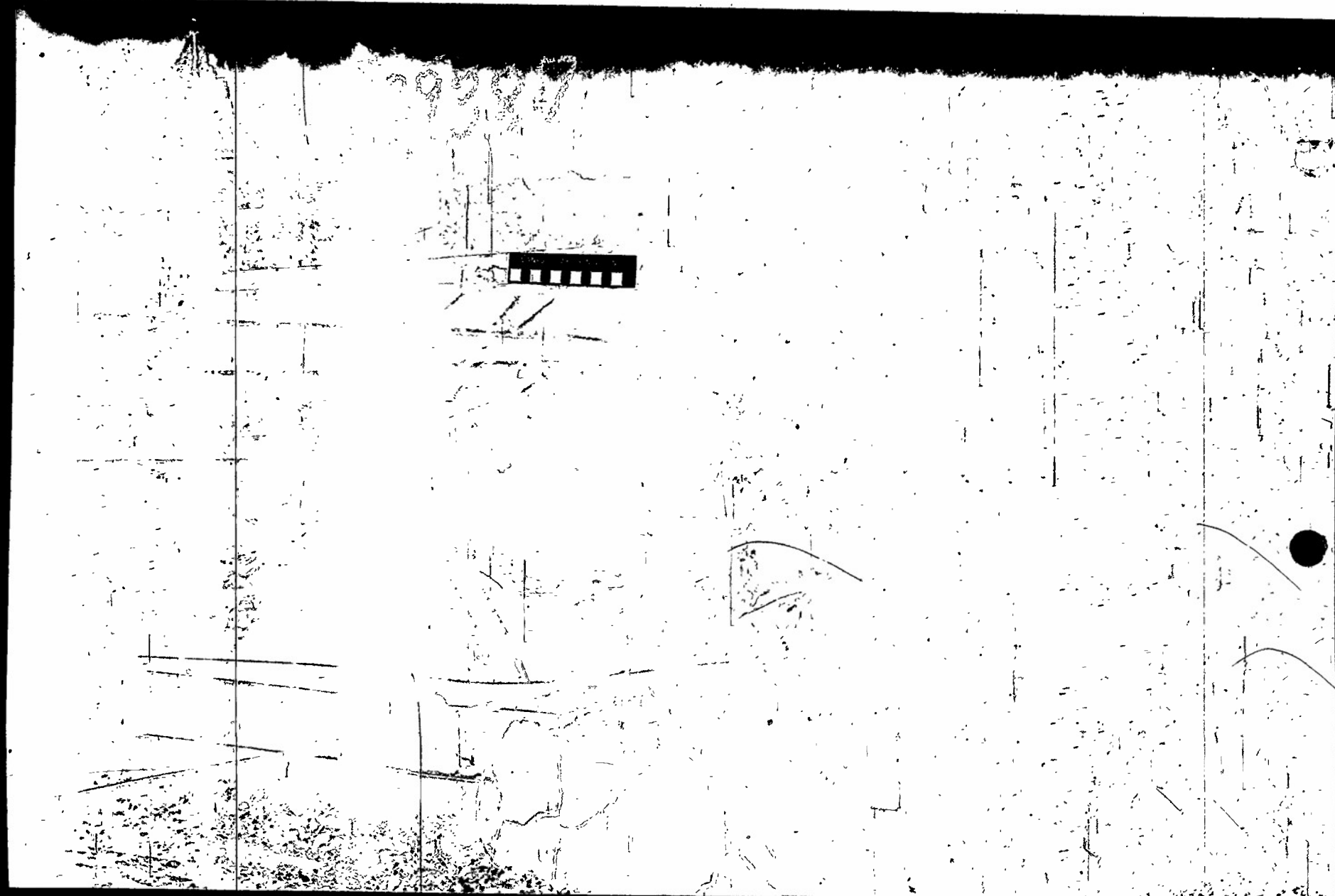
APPENDIX C

NP9-51402 Figure 7 25 October 19 1

Ballistic Test of 1000 lb. Low Drag, A.P. Pont T[illegible] 12.

Imp. No.	Obl.	Thick.	S. V. f/s	Pene.	Remarks
39387	20°	36"	890	35"	Point broke into 2 pieces - Nose through and off. Base stuck in plate.

APPENDIX C



?9-51103 Ti ... 30 October 1951

Ballistic Test of 1300 l ... frag, ... of Type IX 10 and 12.

...p. No.	C.L.	Thick.	.../S	Pene.	Remarks
39413	2.?	24"	...	...	...tive and intact - no defo...ation.

APPENDIX C

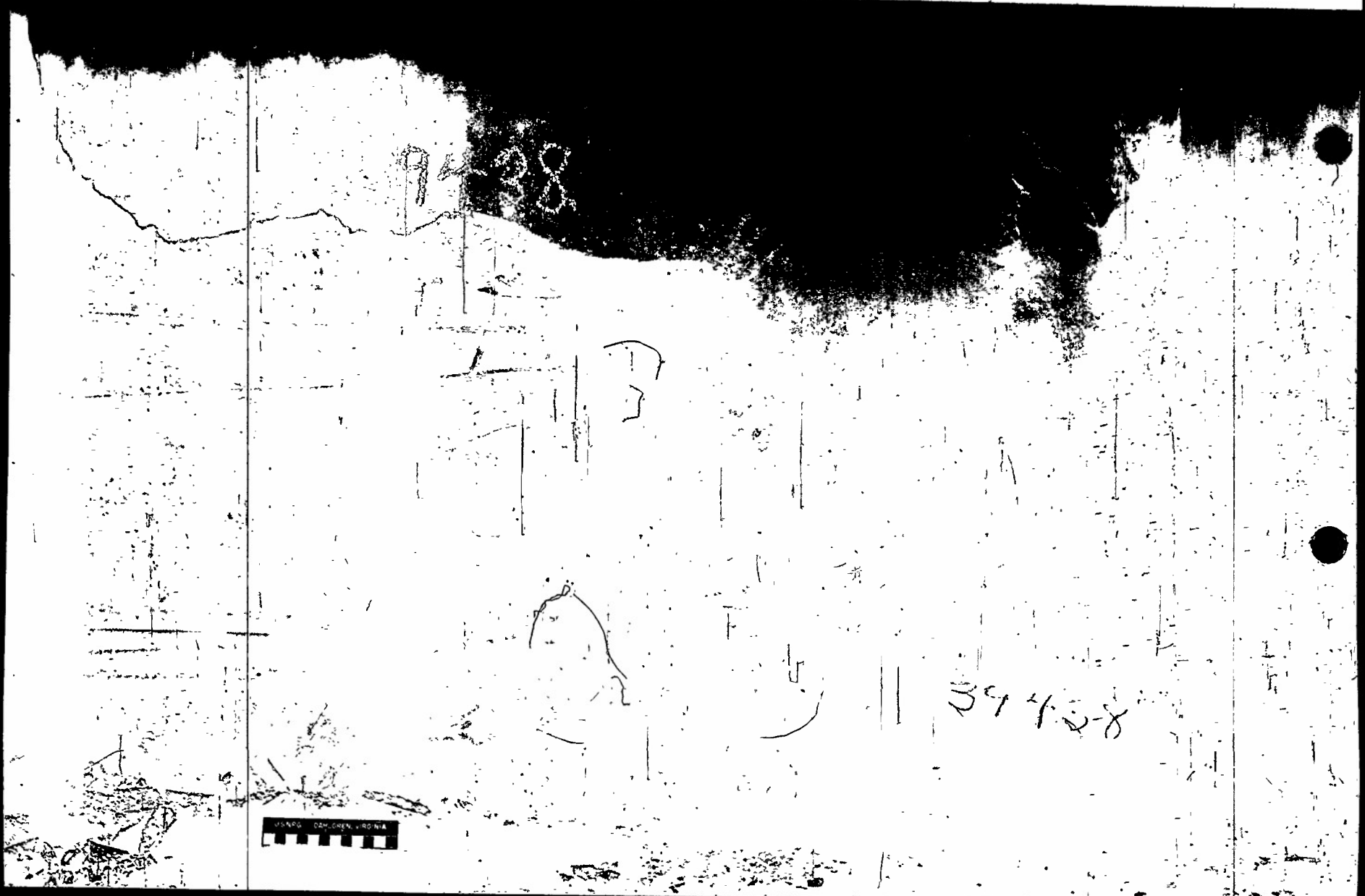
3944

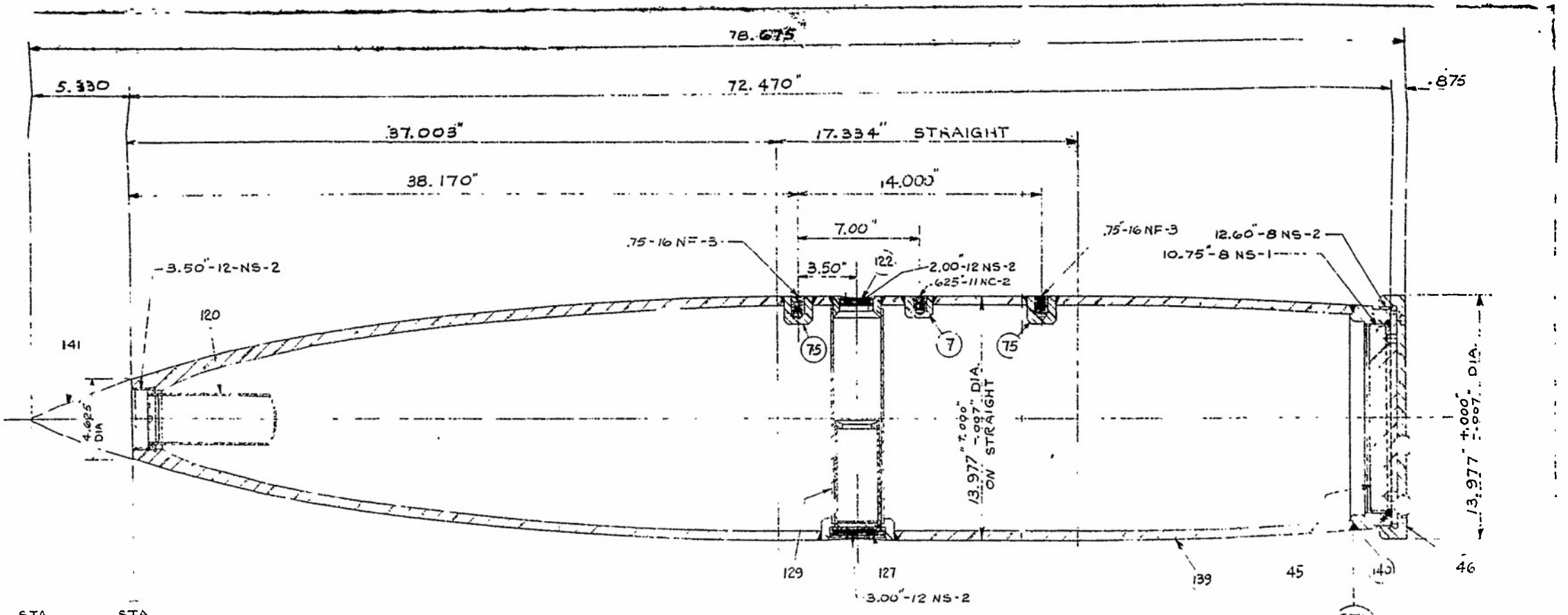
NP9-51404 Figure 9 5 November 1951

Ballistic Test of 1000 lb. Low Drag, G.P. Bomb Type EX 10 Mod 12.

Imp. No.	Obl.	Thick.	S.V. f/s	Pene.	Remarks
39438	20°	30"	886	Inc.	Bomb broke into 2 pieces - nose through and off. Base stuck in block.

APPENDIX C





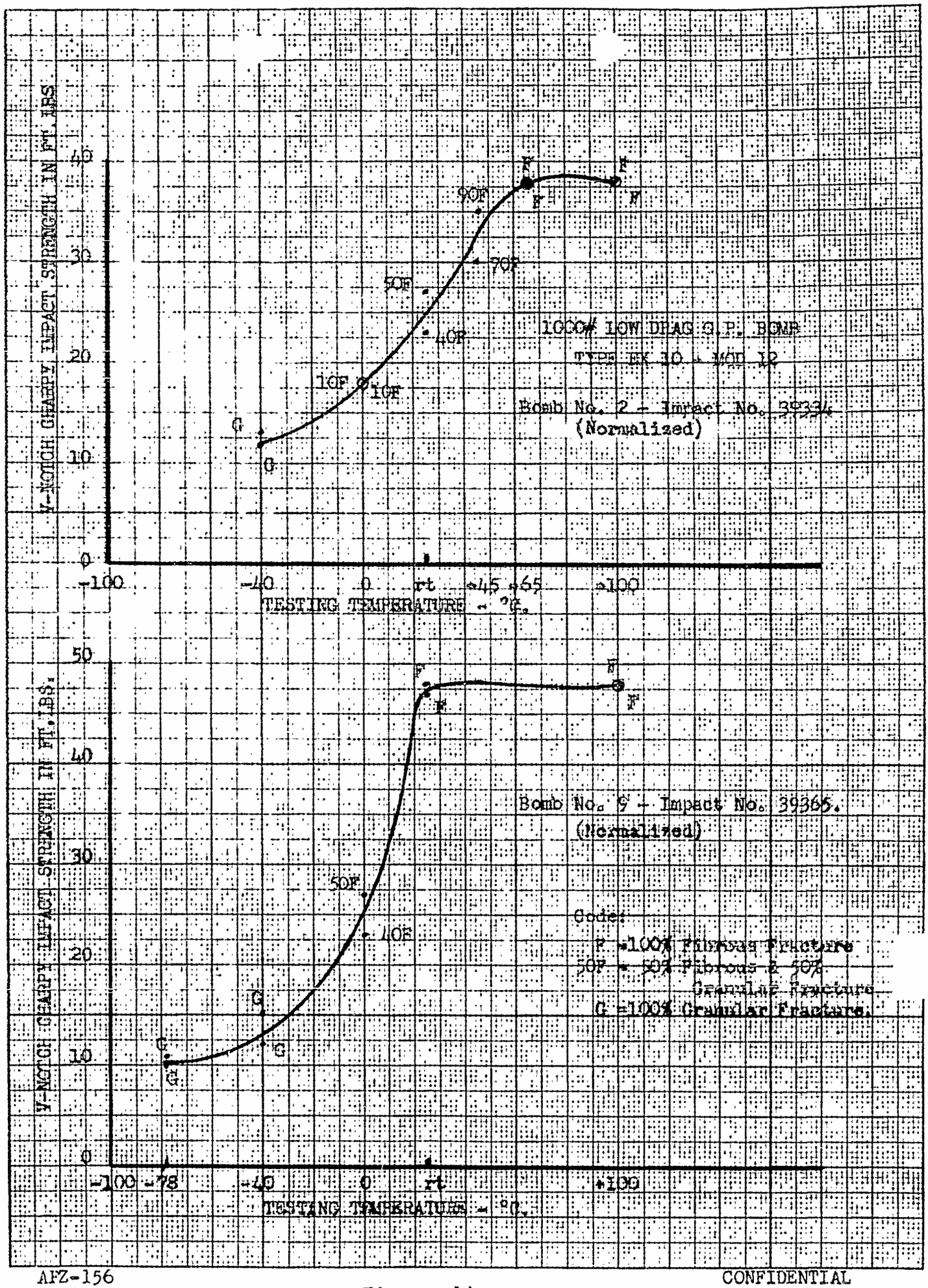
MOD. 12 ASSEMBLY

NOTE:-
APPLY RUST PREVENTIVE COMPOUND MIL-C-972 GRADE II TO BOURRELET ON 17.334 STRAIGHT SECTION OF BODY, THREADED SECTION ON BASE END OF BODY AS SHOWN IN PRELIMINARY SKETCH NOS. 45, 46 AND 139.

ASSEMBLY OF .GUN FIRE. BODY
PRELIMINARY SKETCH NO. 142
DR. BY J.C.S DATE 4-24-51
CH. BY JCS DATE 4-24-51
APP BY EHH DATE 4-26-51

Figure 10 APPENDIX D

T 3412-1.6



AFZ-156

APPENDIX E

Figure 11.

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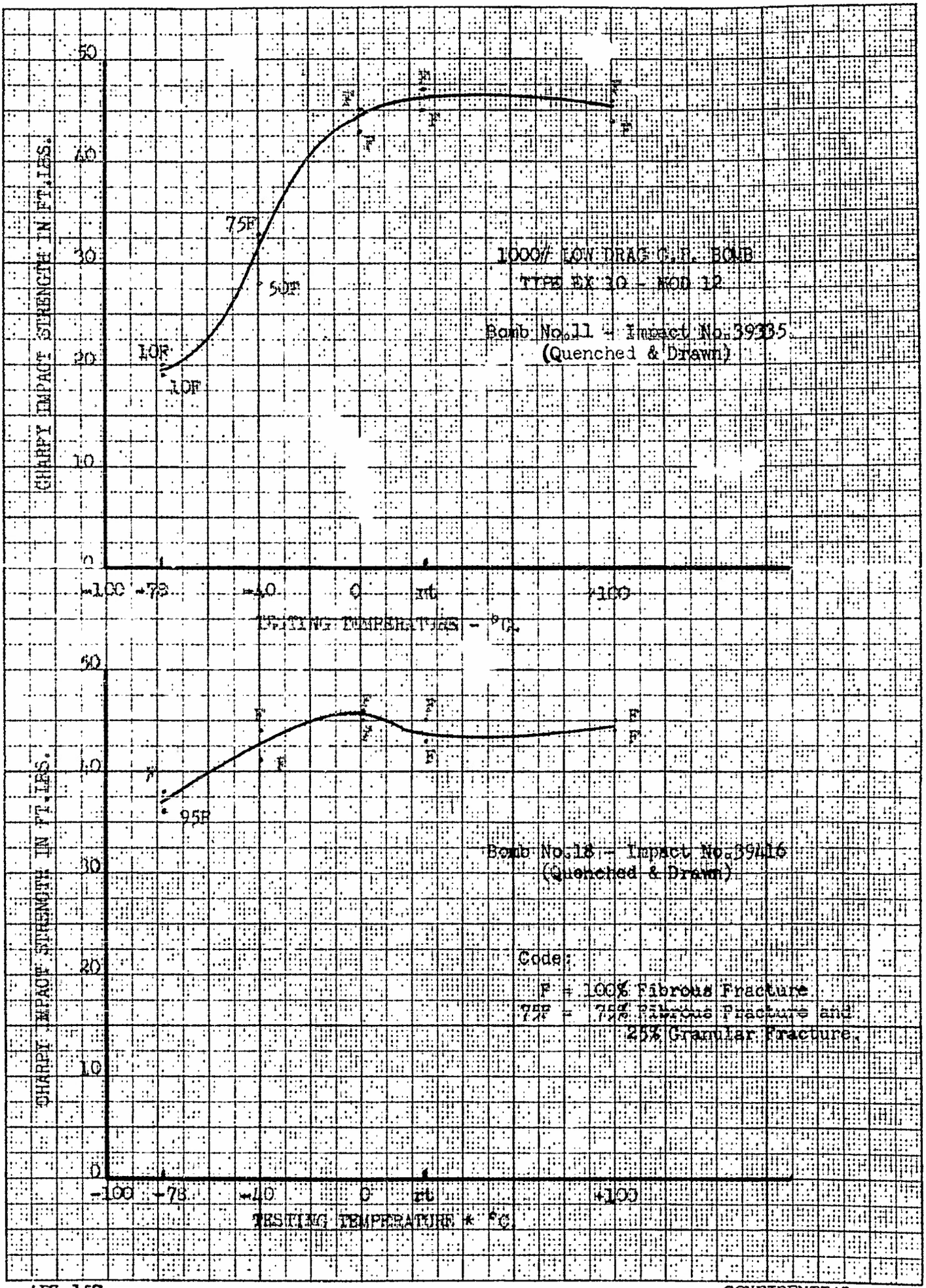


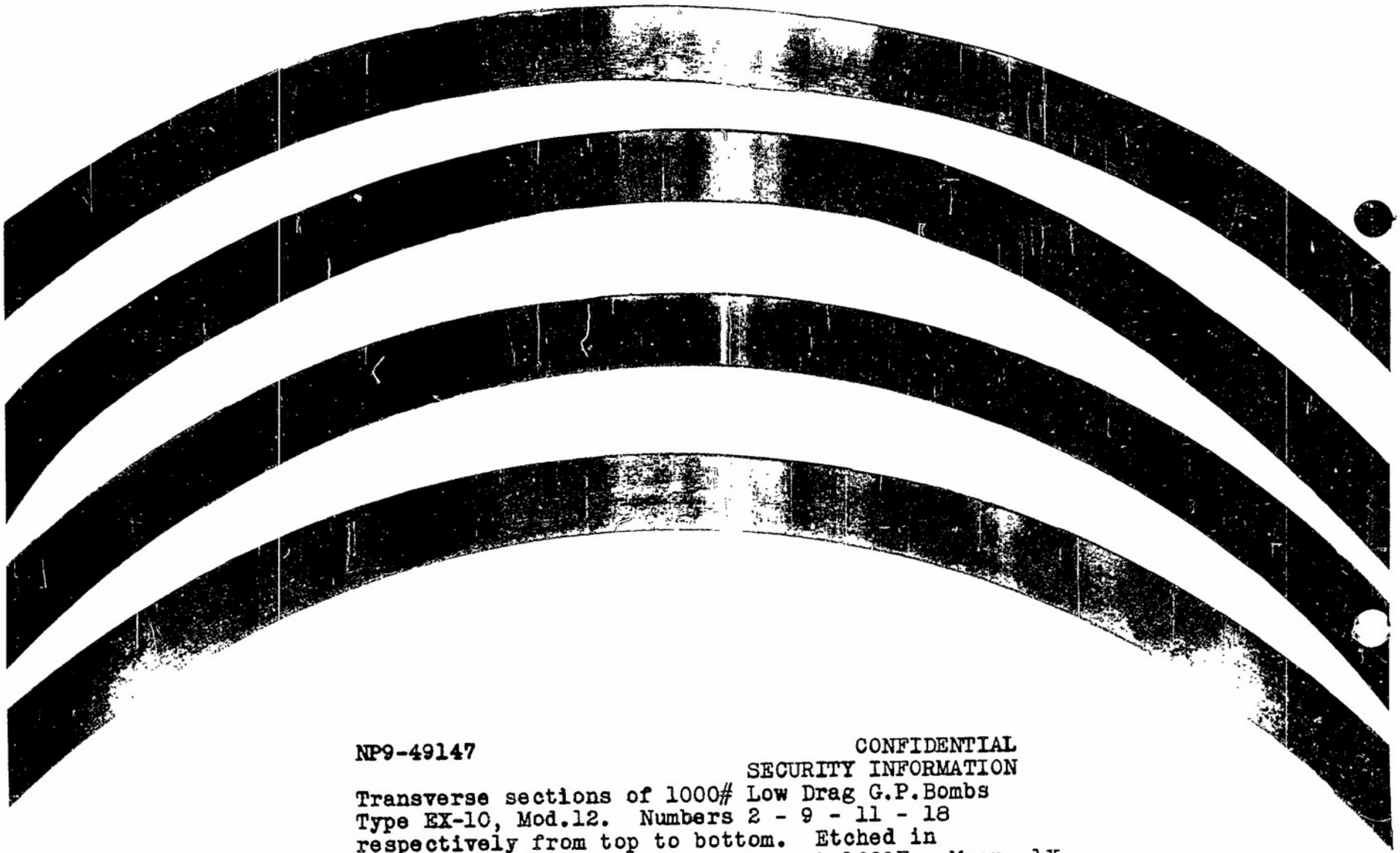
Figure 12.

TABLE XV

V-Notch Charpy Impact Tests at Various Temperatures

Testing Temp.°C	Bomb No. 2 Charpy Ft.Lbs	Bomb No. 2 Fracture *	Bomb No. 9 Charpy Ft.Lbs	Bomb No. 9 Fracture *	Bomb No. 11 Charpy Ft.Lbs	Bomb No. 11 Fracture *	Bomb No. 18 Charpy Ft.Lbs	Bomb No. 18 Fracture *
-78			10	G	19	10F	36	95F
			11	G	20	10F	38	F
-40	12	G	12	G	33	75F	44	F
	13	G	15	G	28	50F	41	F
0	18	10F	23	40F	45	F	45	F
	18	10F	27	50F	43	F	46	F
+25	27	50F	48	F	45	F	43	F
(rt)	23	40F	47	F	47	F	45	F
+45	35	90F						
	30	70F						
+65	38	F						
	38	F						
+100	38	F	48	F	44	F	45	F
	38	F	48	F	46	F	44	F

* F denotes 100% Fibrous Fracture.
10F " 10% " " and 90% Granular Fracture.
G " 100% Granular " .



NP9-49147

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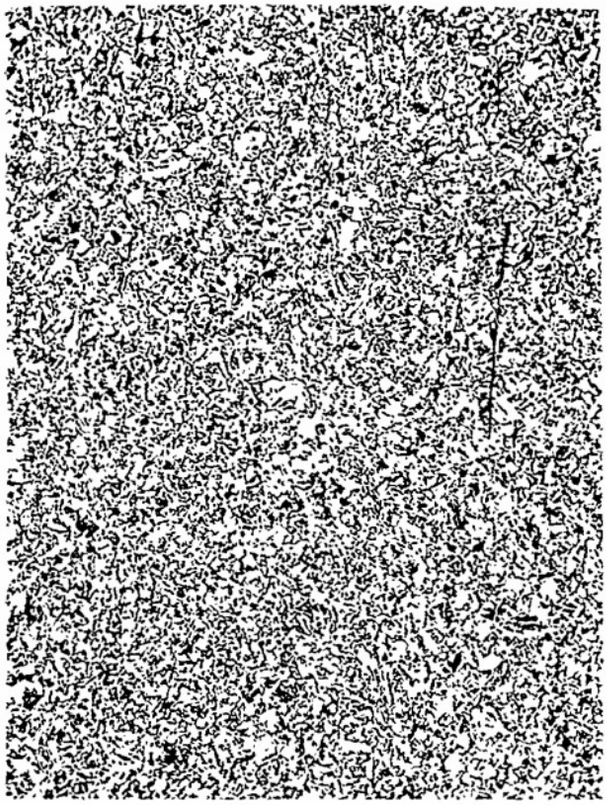
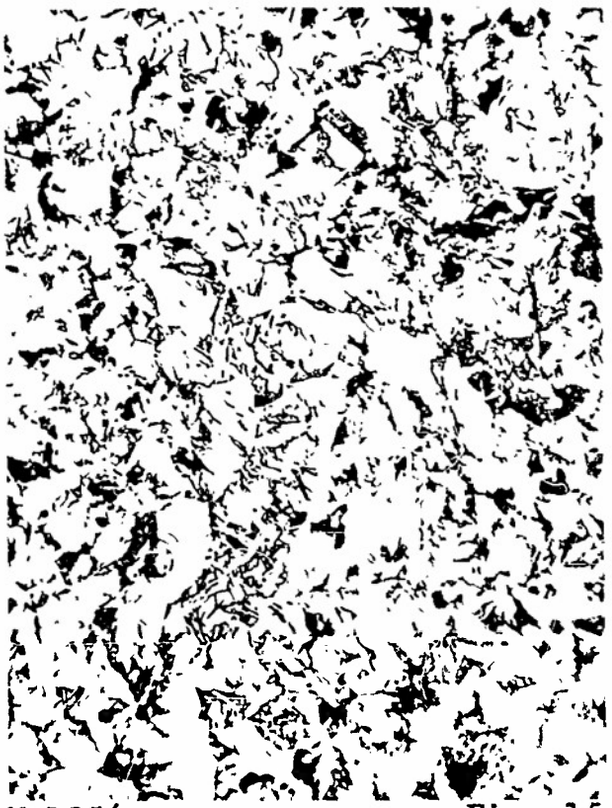
Transverse sections of 1000# Low Drag G.P.Bombs Type EX-10, Mod.12. Numbers 2 - 9 - 11 - 18 respectively from top to bottom. Etched in 50% HCl - 50% H_2O for 20 minutes at 160°F. Magn. 1X

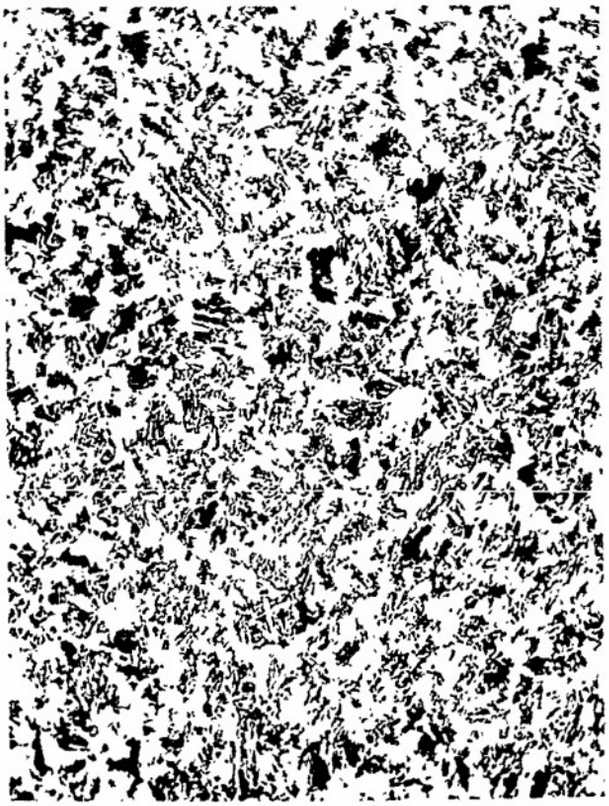
Figure 13.



M-1957 Fig. 14
Bomb No. 2 - Normalized Nital-Picral Etch. Magn. 250X

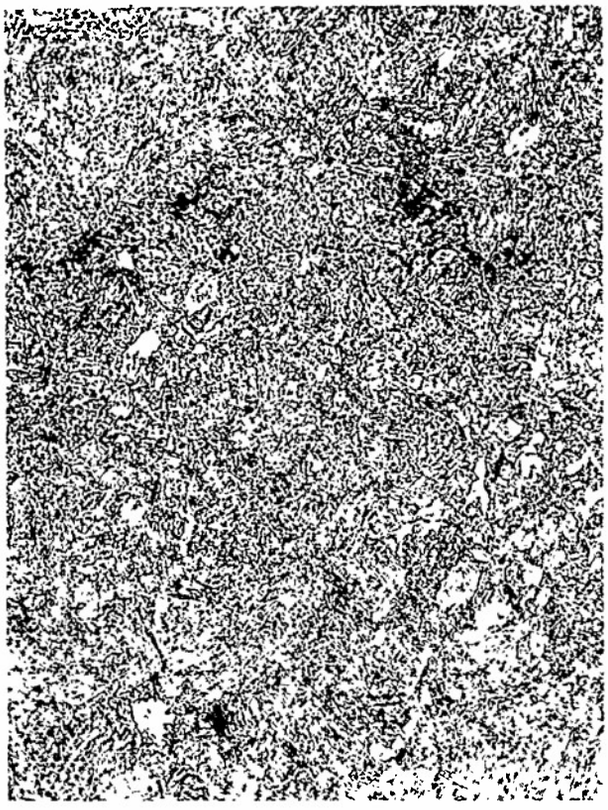


M-1956 Fig. 15
Bomb No. 2 Normalized Nital-Picral Etch. Magn. 1000X



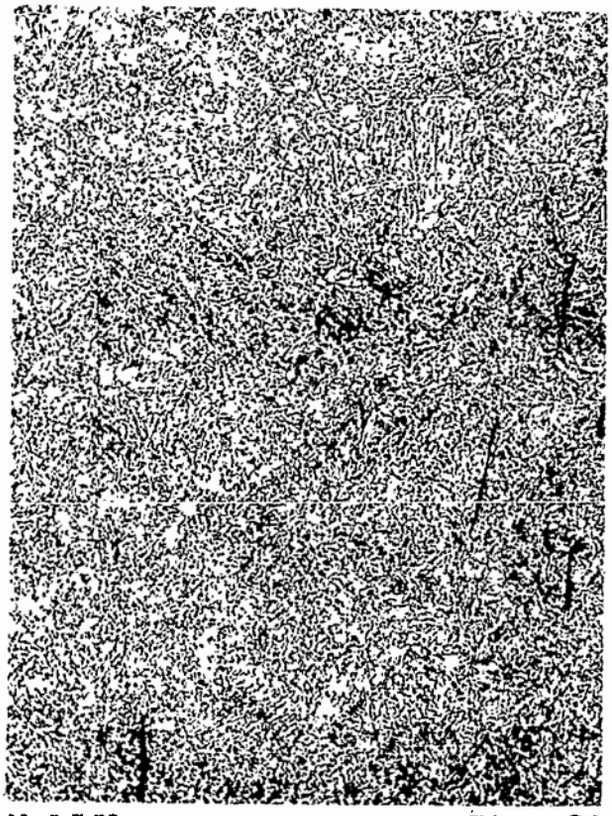
M-1955 Fig. 16
Bomb No. 9 - Normalized Nital-Picral Etch. Magn. 250X

M-1954 Fig. 17
Bomb No. 9 - Normalized Nital-Picral Etch. Magn. 1000X



M-1953 Fig. 18
Bomb No. 11 - Quenched & Drawn
Nital-Picral Etch. Magn. 250X

M-1952 Fig. 19
Bomb No. 11 - Quenched & Drawn
Nital-Picral Etch. Magn. 1000X



M-1951 Fig. 20
Bomb No. 18 - Quenched & Drawn
Nital-Picral Etch. Magn. 250X

M-1950 Fig. 21
Bomb No. 18 - Quenched & Drawn
Nital-Picral Etch. Magn. 1000X

Ballistic Tests of 1000# Low Drag, G.P. Bomb Type EX 10 Mod 12

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